

CLAIMS:

The invention claimed is:

1. A method of forming a conductive metal silicide by reaction of metal with silicon, comprising:

providing a semiconductor substrate comprising an exposed elemental silicon containing surface;  
depositing at least one of a crystalline form TiN, WN, elemental form W, or SiC comprising layer onto the exposed elemental silicon containing surface to a thickness no greater than 50 Angstroms;

exposing the crystalline form layer of thickness no greater than 50 Angstroms to plasma and depositing a conductive reaction layer comprising at least one of an elemental metal or metal rich silicide onto the plasma exposed layer; and

diffusing at least one of metal of the conductive reaction layer or elemental silicon of the substrate along columnar grain boundaries of the crystalline form layer effective to cause a reaction of metal of the conductive reaction layer with elemental silicon of the substrate to form a conductive metal silicide comprising contact region electrically connecting the conductive reaction layer with the substrate.

2. The method of claim 1 wherein the exposing increases degree of columnar grain boundary microstructure within the crystalline form layer from what it was prior to the exposing.

3. The method of claim 1 wherein the crystalline form layer prior to the exposing comprises a predominately columnar grain boundary microstructure.

4. The method of claim 3 wherein the exposing increases degree of columnar grain boundary microstructure within the crystalline form layer from what it was prior to the exposing.

5. The method of claim 1 wherein the metal of the conductive reaction layer diffuses along the columnar grain boundaries of the crystalline form layer.

6. The method of claim 1 wherein the metal of the conductive reaction layer diffuses along the columnar grain boundaries of the crystalline form layer effective to form a predominate portion of the metal silicide from the reaction to be received beneath the crystalline form layer.

7. The method of claim 1 wherein the elemental silicon of the substrate diffuses along the columnar grain boundaries of the crystalline form layer.

8. The method of claim 1 wherein the diffusing and reaction occur during the depositing.

9. The method of claim 1 wherein the diffusing and reaction occur after the depositing.

10. The method of claim 9 wherein the diffusing and reaction do not occur during the depositing.

11. The method of claim 1 wherein the crystalline form layer is of a thickness no less than 5 Angstroms.

12. The method of claim 1 wherein the crystalline form layer is of a thickness from 5 Angstroms to 25 Angstroms.

13. The method of claim 1 wherein the crystalline form layer is of a thickness from 10 Angstroms to 25 Angstroms.

14. The method of claim 1 wherein the crystalline form layer is of a thickness from 15 Angstroms to 25 Angstroms.

15. The method of claim 1 wherein the crystalline form layer is of a thickness from 5 Angstroms to 10 Angstroms.

16. The method of claim 1 wherein the crystalline form layer comprises TiN.

17. The method of claim 1 wherein the crystalline form layer comprises WN.

18. The method of claim 1 wherein the crystalline form layer comprises elemental form W.

19. The method of claim 1 wherein the crystalline form layer comprises elemental form SiC.

20. The method of claim 1 wherein the depositing comprises CVD.

21. The method of claim 1 wherein the depositing comprises ALD.

22. The method of claim 1 wherein the depositing comprises PVD.

23. The method of claim 1 wherein the depositing comprises electroplating.

24. The method of claim 1 wherein the exposed elemental silicon containing surface comprises polycrystalline silicon.

25. The method of claim 1 wherein the exposed elemental silicon containing surface comprises monocrystalline silicon.

26. The method of claim 25 wherein the monocrystalline silicon comprises epitaxially grown silicon.

27. The method of claim 1 wherein the exposing occurs during the depositing.

28. The method of claim 1 wherein the exposing only occurs during the depositing.

29. The method of claim 1 wherein at least some of the exposing occurs prior to and separate of the depositing.

30. The method of claim 29 wherein all of the exposing occurs prior to and separate of the depositing.

31. The method of claim 1 wherein the conductive reaction layer has an outer portion that at least predominately comprises elemental metal.

32. The method of claim 31 wherein the conductive reaction layer outer portion consists essentially of elemental metal.

33. The method of claim 1 wherein the conductive reaction layer has an outer portion that at least predominately comprises metal rich silicide.

34. The method of claim 33 wherein the conductive reaction layer outer portion consists essentially of metal rich silicide.

35. The method of claim 1 wherein the exposing, diffusing and the reaction occur during the depositing.

36. The method of claim 1 wherein the conductive metal silicide formed by the diffusing and reaction has a thickness from 5 Angstroms to 100 Angstroms.

37. The method of claim 1 wherein the exposing, depositing, diffusing, and reaction are effective to form all conductive metal silicide formed over the substrate by the reaction to have no more than 10% thickness variation as determined of a thickest portion of said conductive metal silicide formed by the reaction.

38. The method of claim 1 wherein the exposing, depositing, diffusing and reaction are effective to form all conductive metal silicide formed over the substrate by the reaction to have no more than 1% thickness variation as determined of a thickest portion of said conductive metal silicide formed by the reaction.

39. The method of claim 1 wherein the exposing, depositing, diffusing and reaction are effective to form all conductive metal silicide formed over the substrate by the reaction to have from 1% to 3% thickness variation as determined of a thickest portion of said conductive metal silicide formed by the reaction.

40. The method of claim 1 wherein the exposed elemental silicon containing surface is received within a contact opening formed within an insulative layer.

41. A method of forming a conductive metal silicide by reaction of metal with silicon, comprising:

providing a semiconductor substrate comprising an exposed elemental silicon containing surface;

depositing at least one of a crystalline form TiN, WN, elemental form W, or SiC comprising layer onto the exposed elemental silicon containing surface to a thickness no greater than 50 Angstroms;

exposing the crystalline form layer of thickness no greater than 50 Angstroms to plasma and depositing a conductive reaction layer comprising at least one of an elemental metal or metal rich silicide onto the plasma exposed layer; and

diffusing at least metal of the conductive reaction layer along columnar grain boundaries of the crystalline form layer effective to cause a reaction of metal of the conductive reaction layer with elemental silicon of the substrate to form conductive metal silicide electrically connecting the conductive reaction layer with the substrate, the diffusing and reaction being effective to form a predominate portion of the metal silicide from the reaction to be received beneath the crystalline form layer.

42. The method of claim 41 wherein the diffusing and reaction are effective to form all of the metal silicide from the reaction to be received either a) beneath the crystalline form layer, or b) within the crystalline form layer along the columnar grain boundaries and beneath the crystalline form layer.

43. The method of claim 41 wherein the diffusing and reaction occur during the depositing.

44. The method of claim 41 wherein the diffusing and reaction occur after the depositing.

45. The method of claim 44 wherein the diffusing and reaction do not occur during the depositing.

46. The method of claim 41 wherein the crystalline form layer is of a thickness no less than 5 Angstroms.

47. The method of claim 41 wherein the crystalline form layer is of a thickness from 5 Angstroms to 25 Angstroms.

48. The method of claim 41 wherein the crystalline form layer is of a thickness from 10 Angstroms to 25 Angstroms.

49. The method of claim 41 wherein the crystalline form layer is of a thickness from 15 Angstroms to 25 Angstroms.

50. The method of claim 41 wherein the crystalline form layer is of a thickness from 5 Angstroms to 10 Angstroms.

51. The method of claim 41 wherein the crystalline form layer comprises TiN.

52. The method of claim 41 wherein the crystalline form layer comprises WN.

53. The method of claim 41 wherein the crystalline form layer comprises elemental form W.

54. The method of claim 41 wherein the crystalline form layer comprises elemental form SiC.

55. The method of claim 41 wherein the exposing occurs during the depositing.

56. The method of claim 41 wherein the exposing only occurs during the depositing.

57. The method of claim 41 wherein at least some of the exposing occurs prior to and separate of the depositing.

58. The method of claim 57 wherein all of the exposing occurs prior to and separate of the depositing.

59. The method of claim 41 wherein the conductive reaction layer has an outer portion that at least predominately comprises elemental metal.

60. The method of claim 59 wherein the conductive reaction layer outer portion consists essentially of elemental metal.

61. The method of claim 41 wherein the conductive reaction layer has an outer portion that at least predominately comprises metal rich silicide.

62. The method of claim 61 wherein the conductive reaction layer outer portion consists essentially of metal rich silicide.

63. The method of claim 41 wherein the exposing, diffusing and the reaction occur during the depositing.

64. The method of claim 41 wherein the conductive metal silicide formed by the diffusing and reaction has a thickness from 5 Angstroms to 100 Angstroms.

65. The method of claim 41 wherein the exposing, depositing, diffusing, and reaction are effective to form all conductive metal silicide formed over the substrate by the reaction to have no more than 10% thickness variation as determined of a thickest portion of said conductive metal silicide formed by the reaction.

66. The method of claim 41 wherein the exposing, depositing, diffusing and reaction are effective to form all conductive metal silicide formed over the substrate by the reaction to have no more than 1% thickness variation as determined of a thickest portion of said conductive metal silicide formed by the reaction.

67. The method of claim 41 wherein the exposing, depositing, diffusing and reaction are effective to form all conductive metal silicide formed over the substrate by the reaction to have from 1% to 3% thickness variation as determined of a thickest portion of said conductive metal silicide formed by the reaction.

68. The method of claim 41 wherein the exposed elemental silicon containing surface is received within a contact opening formed within an insulative layer.